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Indirect double regulation and the carbon ETSs linking: The case of coal-fired generation in the EU and China

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ABSTRACT

Double regulation of carbon emissions is a key policy concern in the context of climate change mitigation. The existing literature on double regulation in an emissions trading system (ETS) context has largely focused on the direct type (when, e.g., an ETS and a carbon tax cover the same entity) and has not yet discussed the indirect type (when, e.g., the ETS and carbon tax cover two related entities in the same production-consumption chain). This paper seeks to contribute to the literature by identifying 'indirect double regulation' (ETS & tax) on the coal-fired generation in the EU and China. Specifically, we scrutinized legal documents associated with the coal-fired power and further presented the quantitative evidence of 'double carbon costs'. From the Law & Economics analysis of 'indirect double regulation', we derived implications of 'indirect double regulation' for the abatement of coal-fired power sector in its own jurisdiction and – after a hypothetic linkage between the EU ETS and Chinese national ETS – for its linked partner. In response, policy suggestions are provided to mitigate potential competitive distortions but should differentiate distortions by sources.

1. Introduction

China and the European Union (EU) account for 39% of global carbon emissions in 2015, and the power sector has so far been the largest source of carbon emissions in both jurisdictions (State Grid Energy Research Institute and Yingda Media Investment Group, 2014; Olivier et al., 2016; Eurostat, 2016). Further, coal ranks second after oil as one major primary energy input and plays a major role for power generation in both the EU and China (China electricity council, 2017; Sandbag, 2017). Therefore, reducing carbon emissions in the coal-fired power generation is crucial to climate mitigation efforts, and *coal-related carbon regulation* will be critical in determining whether or not the Greenhouse Gas (GHG) targets can be met.

Emissions trading system (ETS) is the cornerstone of climate policies in both jurisdictions (European Council, 2014; NDRC, 2016). This market-based approach to mitigate GHGs constitutes a cost-effective way to fight global warming. To promote a 'low-carbon coal-fired power system',[2] coal-fired generators in both jurisdictions are covered by emissions trading (i.e. the EU ETS and future Chinese national ETS). Meanwhile, both carbon ETSs coexist with other climate instruments that directly regulate or indirectly affect carbon emissions of the 'ETS-covered entities', leading to a complex climate policy mix (Sorrell and Sijm, 2003) and potential 'double carbon regulation' (hereafter 'double regulation)'.

Double regulation is a key policy concern in the context of climate change mitigation and generally refers to 'significant impacts of policy interactions' when the affected groups pay twice for reducing the same emissions. Within the context of an ETS, different double regulation issues may bring varied effects since different co-existing policies give rise to similar, complementary or in some cases opposite incentive structures in terms of carbon abatement. Some co-existing instruments may incentivize 'long-term investment in low-carbon technology' (Braun et al., 2010; Lanzi and Sue Wing, 2011; Rey et al., 2014) and thus improve dynamic efficiency of an ETS[3]; others may raise aggregate compliance costs while not contributing additionally to abatement.

There are varied examples of double regulation on this matter, and a

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[2] 'Low-carbon coal power system' refers to coal power generation that successfully employ techniques to increase coal use efficiency or directly reduce carbon emissions when generating a given amount of electricity.

[3] Dynamic efficiency involves minimising total costs of achieving climate targets over a long period.

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striking one is the double regulation (double cost burdens) between the carbon ETS and the carbon tax[4] that can occur in both direct and indirect manners. '*Direct double regulation'* has been extensively discussed in the literature and takes place when both instruments (the ETS and carbon tax) are imposed at one party on consuming the same energy products for the same purpose (i.e. to incentivize abatement). However, '*indirect double regulation (hereafter: IDR)'* will arise when the ETS and carbon tax cover two related entities in the same *production-consumption chain* (e.g. electricity producers and consumers). This type of double regulation has not yet been recognized in the literature. If the carbon tax or ETS cost is passed downstream along the vertical production-consumption chain, economic actors (e.g. electricity consumers) will be directly regulated by one policy (e.g. carbon tax on the consumed electricity) and indirectly affected by the other (e.g. the electricity price inflated by generators that are covered by the ETS), resulting in 'IDR'.

Admittedly, legally speaking, it does not constitute double regulation since the co-existing instruments (tax & ETS) concern two separate parties. Nevertheless, the *legal incidence*[5] or the legitimacy of policy mix (i.e. carbon tax and the ETS) is not the only concern. The final economic burden (*economic incidence*) of the policy instruments and the abatement cost structures it incentivizes will determine whether the instruments function effectively. Thus, the (double) cost burden created by the IDR remains crucial to address the question whether the current regulatory framework could incentivize efficient GHG abatement.

As was analyzed above, the existing literature on double regulation in the ETS context has largely focused on the direct type (see, e.g., Johnstone, 2003; Sorrell, 2003; Sorrell and Sijm, 2003; Sijm, 2005; Ellis and Tirpak, 2006; Jakob-Gallmann, 2011; Chiquet, 2015; Schneider et al., 2015) and has not yet identified the indirect one. Further, the economic incidence of a single instrument (e.g. tax or the ETS) has been extensively discussed, but – after the introduction of a second instrument – the 'economic incidence' of double regulation in terms of carbon abatement has not yet been sufficiently discussed. Moreover, despite the extensive literature on the climate policy interactions in the EU context (see, e.g., Río, 2009; Braun et al., 2010; Egenhofer et al., 2011; Lanzi and Sue Wing, 2011; Capozza and Curtin, 2012; Lecuyer and Quirion, 2013; Lehmann and Gawel, 2013; Gawel et al., 2014; Rey et al., 2014; Böhringer et al., 2016), scarce study has examined the climate policy mix in China, let alone its intricate policy interactions. Besides, few studies on double regulation within the context of the ETS barely raise the complications when the ETSs are to be linked.[6]

In light of the gap in the literature and the need to facilitate abatement with regard to coal-fired generation, this paper focuses upon 'IDR in the EU and China', particularly, when the upstream or downstream side of coal-fired generators (ETS-covered entities) is covered by a carbon tax or quasi carbon tax. A 'quasi carbon tax' (e.g. energy tax) is not explicitly imposed on the carbon content of the taxed item, but it will impact emissions/abatement and thus could be economically equivalent to a 'carbon tax'. Further, this paper adopts a Law & Economics perspective to better understand IDR, which rests upon intricate incentive structures and equally complex 'legal details' that may be fully understood only if a holistic view is taken. Specifically, a cost-and-benefit approach is employed to examine the abatement incentive structure of coal-fired generators, and thus to identify environmental effectiveness and efficiency implications of IDR for its own jurisdiction and potential linking partner.

The paper is structured into five sections. Section 2 identifies IDR in both jurisdictions by examining the carbon regulatory framework of coal/coal-fired power and further presents quantitative evidence on the ensuing 'double carbon cost burdens'. The abatement incentive structures of coal-fired generators in both systems are examined in Section 3 (before linking) and Section 4 (after linking) to assess whether and how 'indirect double carbon regulation' will affect the transitioning to a low carbon coal-fired power system. Meanwhile, the 'double carbon costs' (in terms of each megawatt-hour of coal-fired power) in both jurisdictions are compared to show the asymmetric competitive effects of IDR. Section 5 summarizes the main conclusions and proposes potential policy solutions as well as future research suggestions.

2. Examining the carbon regulatory framework for coal-fired power: evidence of IDR

Double regulation ('*double counting*' included) has been discussed in different contexts but attached with multiple and ambiguous interpretations. Specifically, *double counting* occurs when a single unit of GHG emissions or emissions reduction is counted twice towards attaining mitigation pledges or financial pledges (Sorrell and Sijm, 2003; Schneider et al., 2015). 'Double regulation', however, is a much broader concept that extends (beyond 'counting') to the 'significant impacts of policy interactions' and can arise in many different manners.

According to the literature, double regulation within an ETS takes place in two main ways. First, double regulation may occur when the same unit of emissions or emission reductions is counted twice at two separate parties within the same regulatory system. Striking examples include the 'double counting of electricity and heat emissions' in the China ETSs (Chiquet, 2015) and the potential double counting between the Certified Emission Reductions (CERs) and Emission Reduction Units (ERUs) under United Nations Framework Convention on Climate Change (UNFCCC) (Schneider et al., 2015; UNFCCC, 2015). Second, double regulation will take place when the same emissions or emission reductions are counted twice at one party under two separate regulatory frameworks. For instance, 'double cost burdens' will arise from the co-existence between the EU ETS and instruments promoting energy efficiency (EE) or renewable energy (RE) (Sorrell, 2003; Sijm, 2005; Rey et al., 2014).

A third form double regulation that has not yet been acknowledged and discussed in literature regards the abatement obligations or rewards given to two related parties (in the same vertical production-consumption chain) under two regulatory frameworks. An example of this is the IDR in the EU and China that will be elaborated upon below. It arises from the coexistence between the ETS (imposed on coal-fired generators) and a 'carbon tax' or energy tax – associated with coal or coal-fired power – that is charged on the upstream (generation) or downstream (consumption) side of coal-fired plants. Such a tax is examined since it will affect the abatement incentive structures of coal-fired plants. This is explained as follows.

2.1. *'Carbon tax' on coal and coal-fired power*

Currently de jure there is no carbon tax in China nor at the EU level imposed on the carbon content of coal or coal-fired power,[7] and imposing such a tax on the generation or consumption of coal-fired power

[4] Carbon tax refers to the taxation that is explicitly imposed on carbon content of the taxed item (e.g. fuel) for primary purposes of incentivizing abatement.
The Organisation for Economic Co-operation and Development (OECD) defined 'taxation' as 'any compulsory and unrequited payment' to general government, which is different from 'charges' or 'fees' that are paid to government in return for services (OECD, 2001, pp. 15–16; Xu, 2012, pp. 305–306; Milne, 2014, p. 8). In this paper, 'taxation' is interpreted in a broad sense and thus encompasses 'charges' and 'fees' (to government) as well.

[5] The 'legal incidence (or burden)' of tax (i.e. whether it is directly collected on buyers or on sellers) has no effect on the 'economic incidence' of the tax – the respective shares of the tax burden borne by consumers and producers. See Frank (2007) p. 50, Griffiths and Wall (2008) pp. 57–58.
Carbon ETS costs of the ETS-covered entities (e.g. generators) could also be passed on to non-ETS-covered entities (e.g. downstream power consumers). See, e.g., IEA (2003), Frondel et al. (2012) pp. 105–106, Schröder et al. (2013) p. 2, Bönte et al. (2015).

[6] Two ETSs are linked if one country's allowance can be used, directly or indirectly, by a participant in the other country's scheme for compliance purposes. See Haites (2004) p. 5.

[7] This paper merely discusses taxes on EU level, though on member state level there exist carbon taxes (e.g. in Finland, Ireland and Sweden).

Table 1
A comparison of 'carbon tax' (on coal and coal-fired power) between the EU and China.
Source: Council of the European Union (2003), State Administration of Taxation (2015), European Commission (2016).

	China	EU
On coal (produced/consumed to produce electricity)	Ad-valorem tax; imposed on coal plants when coal is sold; tax rates: 2–9% (varied in different provinces, see Fig. 3).	N/A (at coal plants); exempted (at coal-fired generators).
On electricity (coal-fired power included)	N/A	Ad-Quantum tax; minimum tax rates (EU-wide): 0.5 euro/MWh (business use); 1.0 euro/MWh (non-business use). Further, effective energy tax rates on electricity in different member states vary, *see* Figs. 1 and 2 (with different exemptions).[a]

[a] For instance, in Germany, electricity consumers exceeding threshold may get tax reductions through reimbursement. Exemptions to electricity tax include, *inter alia*, the manufacturing sectors in various production processes (electricity used for electrolysis, production of glass, ceramics, fertilizers, metal production and processing, as well as chemical reduction, since 2006). See Flues and Johannes (2015).

remains unclear in both jurisdictions. In 2011, European Commission presented a proposal to restructure the taxation of energy products by taxing energy in a way that reflects both its CO_2 emissions and its energy content. But the proposal was withdrawn by the Commission, following the unsuccessful negotiations between the EU Member States in the Council (European Commission, 2011a, 2011b). In China, the resistance to a carbon tax has been stronger than anticipated as it gave rise to strong concerns about adverse impacts on the economic development, international competitiveness and social distributional complications (Zhao, 2014; Ideacarbon, 2016a). According to China's former Finance Minister, Jiwei Lou, a carbon tax will not be separately introduced in China *but* may be implemented as one sub-item of a tax within the current arrangements, e.g. resources tax or environmental tax (Ideacarbon, 2016a).[8] Also, it is generally believed that a carbon tax in China may be imposed on the non-ETS-covered entities after 2020, mainly complementing the coverage of the ETS (Ideacarbon, 2016b).

While a *de jure* carbon tax remains uncertain in both jurisdictions, 'energy taxes' (or *quasi* 'energy taxes') are imposed on the vertical production-consumption chain of coal-fired power. Such excise duties directly impact coal use and coal-related carbon emissions and are thus to a certain degree similar to a 'carbon tax' on coal or coal-fired power. Therefore, they could be deemed as 'de-facto carbon tax' or 'quasi carbon tax' (see Table 1).

In the EU, the Energy Tax Directive (ETD, Directive 2003/96/EC), adopted in 2004, sets the minimum energy tax rate for the energy products used in transport, the production of heat and the consumption of electricity (coal-fired power included) (Council of the European Union, 2003). Consumption of electricity from renewable origin (e.g. solar and wind power) may enjoy total or partial exemption (Council of the European Union, 2003). Further, energy products used for the production of electricity (e.g. coal) are exempt from the ETD. Additionally, it has to be stressed that the EU ETD is energy-input neutral.[9]

There is no comparable tax measure comparable to the EU's ETD in China that explicitly pursues environmental protection or efficient energy use. But it is generally argued that a *quasi* 'energy tax' is implicitly embodied in other taxes, mainly the resources tax and consumption tax that are levied on energy products and incentivize efficient energy use (Xu, 2012; Liu and Sun, 2014).[10] While the consumption tax is currently levied on energy resources such as gasoline and diesel and does not yet extend to coal, the resources tax is the main tax measure that is currently imposed on coal at coal plants, i.e. coal mine operators (State Administration of Taxation, 2015). Consequently, the Chinese resources tax (imposed on the coal plants) is the only de-facto tax item that is comparable to the energy tax in the EU in the sense that both tax measures incentivize abatement at coal-fired generators.[11]

2.2. IDR between the ETS and 'carbon tax'

As postulated above, the energy tax (on coal-fired power) in the EU and the resources tax (on coal) in China could be deemed as '*de-facto* carbon tax' in the sense that it puts an additional cost burden on coal fired power generation. These tax measures may therefore overlap with the ETSs and give rise to IDR, as the ETSs directly cover the coal-fired plants in both jurisdictions.

Although the EU ETS applies to the large-scale production of electricity and heat and is directly linked to carbon emissions, there is relatively – though little – direct target group overlap between the two instruments (the ETS and the ETD) at both sides of generation and consumption. On the one hand, electricity end users (if not in the exempt sectors) will be covered twice for consuming the same electricity by both the ETS and the ETD (double carbon costs) (Rey et al., 2014).[12] On the other hand, the use of coal for electricity generation by coal-fired power plants is exempt from the ETD (to avoid direct double regulation) (Council of the European Union, 2003).

Granted that such a 'direct double regulation' is avoided, still, there is 'indirect double regulation (IDR)' that has not yet received sufficient attention but has been embodied in the production-consumption chain of coal-fired power. This is because, on the one hand, coal-fired power consumers are required to pay directly the energy tax under the ETD for the consumption of coal-fired power (see Fig. 1 (business) and Fig. 2 (non-business)).[13] On the other hand, coal-fired power plants – covered by the EU ETS – have passed the carbon cost to coal-fired power consumers by inflating the price of coal-fired power, which has been extensively discussed in the literature (see, e.g., IEA, 2003; Frondel et al., 2012; Schröder et al., 2013; Bönte et al., 2015). Specifically, in line with the methodology adopted by Weishaar (2017), we measured the 'ETS cost burdens' imposed on each megawatt-hour of coal-fired power in the high-emitting EU member states (see Table 3). This is done by multiplying the 'emissions intensity for coal-fired generation' (Table 2) and the 'annual EUA prices'. The average 'emissions intensity for coal-

[8] Currently there exists no 'environmental taxation' in strict sense in China.

[9] Energy tax is not imposed on the energy content or carbon content of the taxed items in the EU. See European Commission (2011b), Rey et al. (2014) pp. 11–12, 47.

[10] Other types of local coal-related fees are not discussed since they are not standardized, oftentimes charged repeatedly and are likely to be integrated into a unified resources tax during the current coal resources tax reform. See China Coal Net (2009), Daily Economic News (2014), Chang and Wang (2016).

[11] Admittedly, energy tax (as product tax) and resources tax are different in their 'de jure' taxation purposes and tax designs (e.g. tax bases) (see Milne and Andersen, 2012), but they bear similar 'de facto impacts' in terms of abatement at coal-fired generators, which is to be explained in Section 3.

[12] To avoid 'double regulation' in this sense, the above-mentioned European Commission proposal on restructuring energy taxation also encompassed the differentiation between sectors covered by the EU ETS and those that are not (European Commission, 2011a, 2011b).

[13] 'Business' is more concerned with 'economic activity', while 'non-business' generally refers to activities that do not generate any income, directly or indirectly.

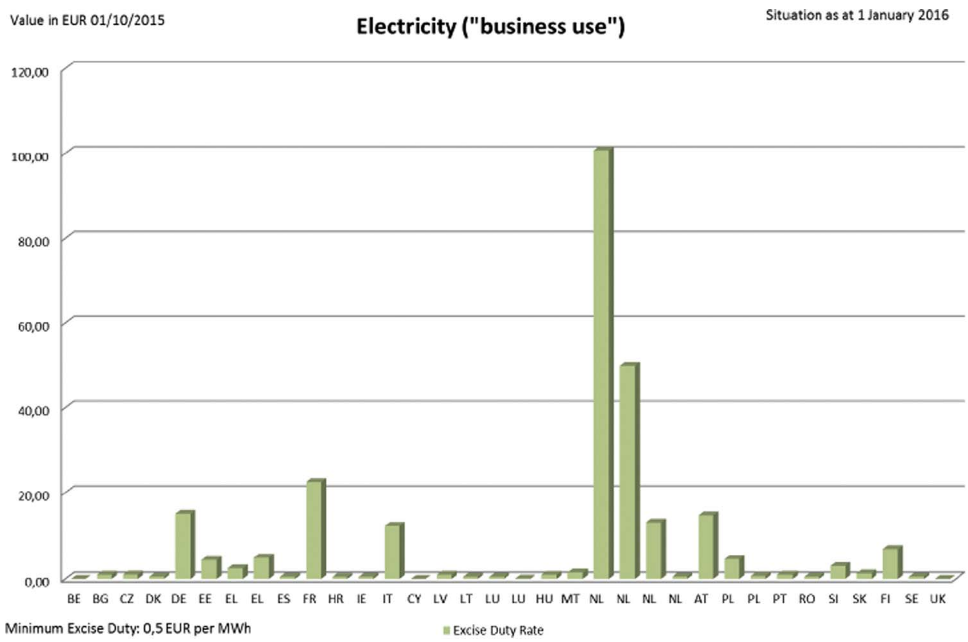

Fig. 1. Effective energy tax rates on electricity in the EU (business use).
Source: European Commission (2016).

fired generation' is calculated on the basis of data on the 'emissions from the coal-fired generation' from Sandbag (2017) and the 'electricity output by coal' from EEA (2016).

Consequently, coal-power end users in the industrial sectors (if not in the exempt sectors of the ETD) have to pay 'carbon costs' twice for consuming the same electricity, including both the 'carbon tax' embodied in the ETD and the 'indirect carbon ETS cost' that is embodied in the inflated coal-fired power price. Accordingly, we provided the quantitative evidence on the 'double carbon cost burdens of ETS & tax' in terms of each megawatt-hour of coal-fired power (see Table 4). Admittedly, this does not constitute double regulation in legal sense, but the IDR ('double cost burdens') or, at the very least, 'indirect policy interactions' will *de facto* affect coal-power end users' consumption behaviors, shape the abatement incentive structures of upstream coal-fired generators and consequently merits further attention.

While the IDR arises at the consumer level in the EU, similar problem takes place in China at the side of coal-fired power plants.

As described above, the Chinese resources tax is an ad-valorem tax imposed on coal plants when coal is sold (see Fig. 3). By inflating the price of coal, the resources tax could be (at least in part) passed onto coal consumers in general and to coal-fired power generators in particular. The extent to which tax can be passed downstream depends upon the 'market power' of coal plants and thus largely upon the price elasticity of demand for thermal coal at coal-fired plants (Frank, 2007; Griffiths and Wall, 2008; Perloff, 2008), particularly, in the thermal coal market. Such an elasticity will be essentially determined by the extent to which coal-fired generators have the opportunity to 'respond' (to the price change in the domestic market) within the timeframe under consideration. First, since both electricity prices and generation output remain highly regulated by the government (NDRC, 2015a), coal-power plants can neither inflate the price (on-grid tariff) to pass down coal costs, nor can they adjust the generation output and thus the coal use (*ceteris paribus*, e.g. with a given technique and fuel mix for generation) (Kahrl et al., 2011). Further, generators can, of course,

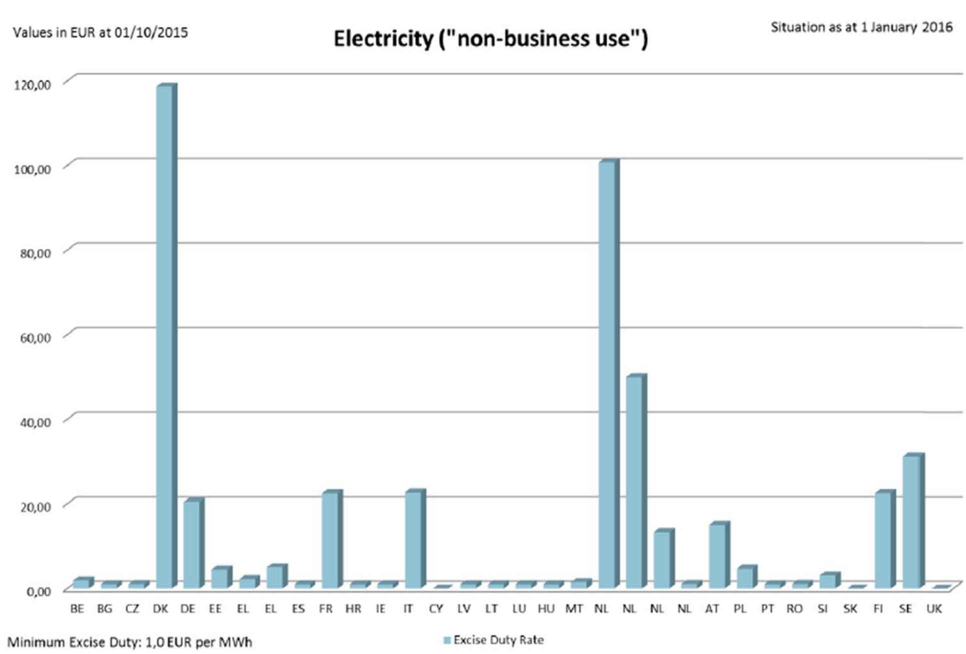

Fig. 2. Effective energy tax rates on electricity in the EU (non-business use).
Source: European Commission (2016).

Table 2
CO_2 emission intensity for coal-fired generation by high emitting countries in the EU (gCO_2/kWh) (2010–2014).
Source: Authors' own calculation on the basis of data from EEA (2016) and Sandbag (2017).

	EU-28	Germany (DE)	Poland (PL)	Czech Republic (CZ)	Italy (IT)	Netherlands (NL)	Bulgaria (BG)
2014	981.92	966.07	997.53	1121.59	906.71	868.24	1215.68
2013	981.10	969.11	1002.05	1129.36	908.99	897.86	1232.47
2012	986.17	974.64	1012.09	1131.63	889.28	838.43	1210.88
2011	995.52	994.02	1003.88	1154.52	903.28	808.79	1151.18
2010	1000.70	993.93	1016.01	1165.28	933.71	827.87	1172.26

Table 3
ETS cost burdens by high emitting countries in the EU (EUR/MWh) (2010–2014).
Source: Authors' own calculation on the basis of data from Table 2 and Borghesi et al. (2016).

	Average annual EUA price (EUR/tCO_2)	ETS cost (EUR/MWh)						
		EU-28	Germany (DE)	Poland (PL)	Czech Republic (CZ)	Italy (IT)	Netherlands (NL)	Bulgaria(BG)
2014	5.95	5.84	5.75	5.94	6.67	5.39	5.17	7.23
2013	4.46	4.38	4.32	4.47	5.04	4.05	4.00	5.50
2012	8.12	8.01	7.91	8.22	9.19	7.22	6.81	9.83
2011	14.09	14.03	14.01	14.14	16.27	12.73	11.40	16.22
2010	15.25	15.26	15.16	15.49	17.77	14.24	12.63	17.88

Table 4
Double carbon cost burdens (ETS-tax) by high emitting countries in the EU (EUR/MWh) (2014).
Source: Authors' own calculation based on data from Table 3 and European Commission (2016).

		Germany	Poland	Czech Republic	Italy	Netherlands				Bulgaria
						0–10,000 kWh	10,000–50,000 kWh	50,000–10,000,000 kWh	> 10,000,000 kWh	
Business	**ETS cost**	5.75	5.94	6.67	5.39	5.17	5.17	5.17	5.17	7.23
	Energy tax (on electricity)	15.37	4.71	1.04	12.5	100.7	49.96	13.31	0.53	1
	Double cost burdens	21.12	10.65	7.71	17.89	105.87	55.13	18.48	5.70	8.23
Non-business	**Energy tax (on electricity)**	20.5	4.71	1.04	22.7	100.7	49.96	13.31	1.07	1
	Double cost burdens	26.25	10.65	7.71	28.09	105.87	55.13	18.48	6.24	8.23

Note: Electricity tax in Spain is not listed herein as it has a general ad-valorem tax rate of 5,113% on a base that excludes VAT, except for cases in which this leads to a lower tax, in which minima apply.

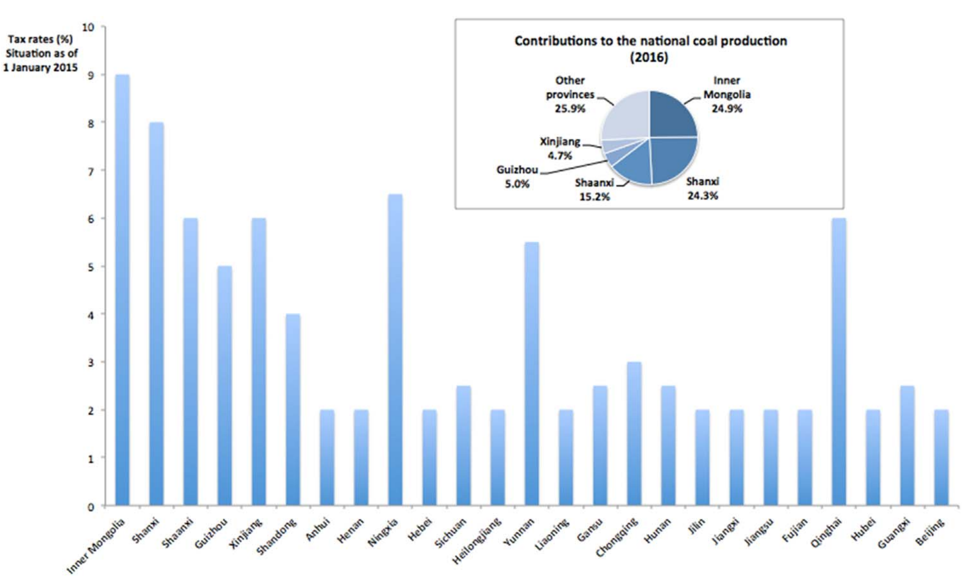

Fig. 3. Resources tax rates on coal and provincial coal production in China.
Source: Own elaboration on the basis of data from Provincial Official Websites.

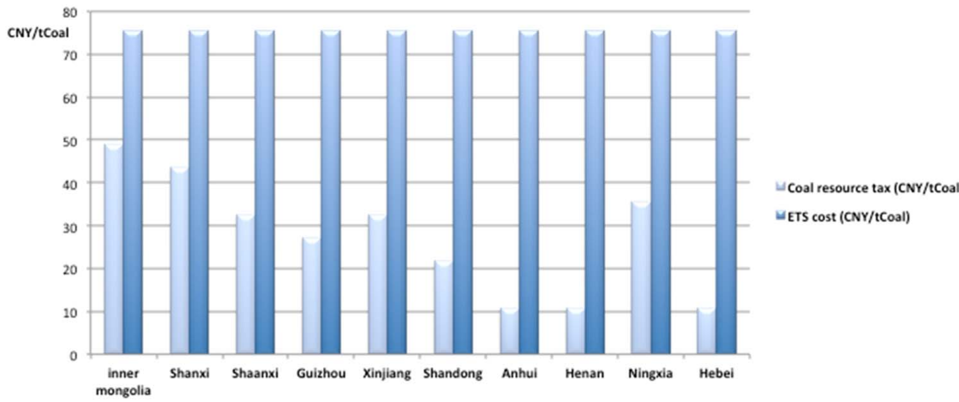

Fig. 4. Double carbon cost burdens by 10 largest coal-producing provinces in China (Bituminous coal-5000 Kcal/kg) (CNY/tCoal).
Source: Authors' own elaboration.

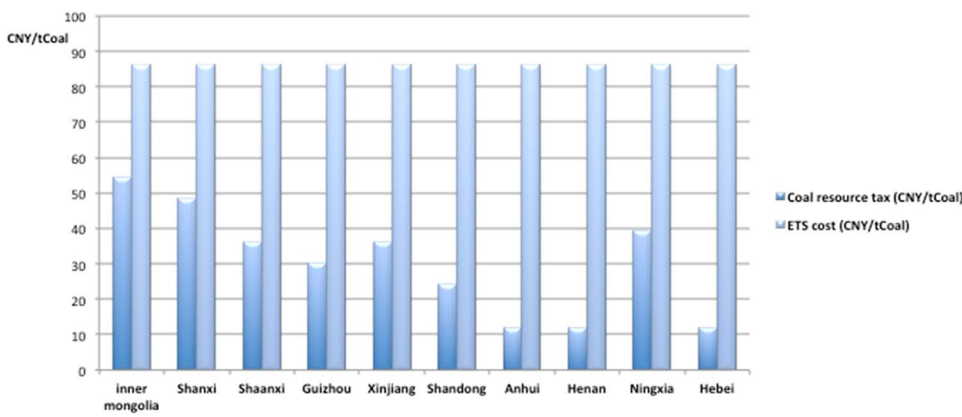

Fig. 5. Double carbon cost burdens by 10 largest coal-producing provinces in China (Anthracite-5500 Kcal/kg) (CNY/tCoal).
Source: Authors' own elaboration.

purchase coal from the international market, but such importation remains limited in practice for multiple reasons such as regulatory risk or financial risk, e.g. the limited permits issued for coal importation.

As a result, the price elasticity of demand for thermal coal at coal-fired generators will be essentially 'relatively inelastic', which is also corroborated by an empirical study of thermal coal consumption (January 2001-August 2015) that shows the price elasticity of demand for thermal coal in China is − 0.1397 in the short term and − 0.254 in the long term (Qiao and Luo, 2016). Due to the inelastic demand, coal-fired power generators will have to bear a large part of the resources tax and incur higher coal costs. Because coal-fired generators are also subject to the Chinese ETS, the IDR will take place at the coal-fired plants as they will pay both the 'direct carbon ETS costs' and 'indirect carbon tax' (i.e. the resources tax that is passed from upstream coal plants and embodied by the coal cost increase).

Below we present a preliminary magnitude of 'double carbon cost burdens' on coal-fired generators in the 10 largest coal-producing provinces in China. We examine in particular the two common types of thermal coal including the bituminous coal-5000 Kcal/kg and anthracite-5500 Kcal/kg (Figs. 4 and 5). Specifically, the 'ETS cost burdens on generators from coal-combustion' in the future Chinese national ETS are estimated by multiplying the 'carbon emissions from coal combustion (tCO_2/tCoal)' and the 'projected ETS prices (CNY/tCO_2)' (see Table 5).

3. Mixed effects of the IDR in the EU and China: a Law & Economics justification?

Building upon the proceeding sections, this section presents a Law & Economics analysis of IDR in both jurisdictions and identifies its environmental effectiveness and efficiency implications. Specifically, the incentive structure of coal-fired generators in both systems will be examined to analyze whether and how such IDR will induce a low-carbon transformation of the power generation sector.

Different forms of double regulation (between the ETS and 'carbon tax') may lead to varied effects, particularly, in relation to whether or not such a tax covers the ETS-covered entities.

On the one hand, if the carbon tax covers the ETS-covered entities, a hybrid tax-ETS system enables the regulators to limit the overall quantity of emissions while influencing the market price (Weishaar and Tiche, 2014). But a hybrid system will very likely induce a higher administrative burden upon companies and thus give rise to higher aggregate abatement costs in the ETS sectors, which is inefficient. Also, the installations that fall under both systems pay twice for emitting one ton of CO_2 (double payment), which leads to inefficiency if the total price paid does exceed the 'social optimum price' for carbon emissions (Böhringer et al., 2016). Moreover, significant competitive distortions could arise between those who pay twice and those installations that only fall under one system. Accordingly, because installations have different marginal abatement costs, the 'internalisation of emission externality' cannot be achieved at least costs. This is inefficient.

Further environmental implication of such a hybrid system (tax & ETS) is that it does not generate additional emission cuts *but* incentivises long-term abatement. This is because theoretically a carbon tax (or quasi carbon tax) provides a clear and continuous incentive for abatement by sending a clear price signal and also leads to government income (Weishaar and Tiche, 2014). But once the cap is set, the cap under the ETS fixes total CO_2 emissions and further tax measures imposed on the ETS-covered entities will not result in additional emission cuts.[14] However, in the long term, an ETS is not so effective as to spur

[14] It bears mentioning that if the carbon tax rate is set much higher than the carbon market price, the ETS will simply be superseded (or even nullified) by carbon tax. Admittedly, such a carbon tax will certainly give rise to additional abatement (to the abatement target within the ETS), but it is rarely likely that policy-makers will implement such a hybrid ETS-tax system.

Table 5
Projected ETS cost burdens on generators from coal-combustion in the Chinese national ETS (CNY/tCoal).
Source: Authors' own calculation on the basis of data from Climate Change Department of NDRC (2014), de Boer et al. (2015), Teng (2015), Tianjin Port Exchange Market (situation of 2017-05-10).

	Coal price (CNY/tCoal)	Net calorific value (GJ/t)	Carbon content (kgC/GJ)	Oxidation ratio	Average emissions factor (tCO_2/tCoal)	Projected national carbon price (CNY/ tCO_2)	ETS cost (CNY/tCoal)
Bituminous coal – 5000 Kcal/kg	545	20.37–23.73	26.59–27.02	83.6–99%	0.527	39	75.36
Anthracite – 5500 Kcal/kg	605	22.31–25.87	26.8–27.65	86.1–99%	0.603	39	86.23

Note: Emissions factor in 'IPCC Guidelines for National Greenhouse Gas Inventories' is not adopted since the categorization *therein* (e.g. for anthracite and bituminous coal) is different from Chinese practice (*i.e.* GB/T5751 categorization).

innovation in new low-carbon technologies by itself, mainly because it cannot provide any certainty about setting (sufficiently and consistently) high carbon price signal (Capozza and Curtin, 2012; Lecuyer and Quirion, 2013; Lehmann and Gawel, 2013; Gawel et al., 2014; Weishaar, 2014a; Zeng et al., 2016), unless certain mechanisms (e.g. reserved auction prices) are expressly introduced to do so. Since carbon tax revenues are commonly used to fund R & D programmes or provide subsidies and tax reductions for the adoption of low-carbon technologies (Braun et al., 2010; Lanzi and Sue Wing, 2011), the interaction of the ETS and carbon taxes may have positive impacts on innovation and thus incentivize long-term abatement.

On the other hand, different effects may arise when a 'carbon tax' imposes 'abatement obligations' on the non-ETS-covered entities. Specifically, the current policy mix in the EU and China may generate a wide variety of explicit and implicit complications. The explicit carbon price drop – in the wake of IDR – *prima facie* brings down aggregate abatement costs. But the implicit distortions of carbon price signal within the policy mix may complicate the mechanism. Generally, the use of a second instrument that interacts with the ETS will raise the overall costs of meeting the emissions cap and thus reduce efficiency. This is explained below.

3.1. Explicit complications of IDR

As presented above IDR arises in the context of coal-fired power at different levels. In the EU it arises at the consumption level while in China it arises at the generator level. Twofold effects may arise when coal-power consumers in the EU pay double 'carbon costs' (direct 'electricity tax' and indirect 'carbon ETS costs') for the consumption of coal-fired power. In the short term, consumers will seek to reduce such consumption and thereby affect upstream emissions of coal-fired generators ('upstream-downstream effect'). Consumers in the EU have some flexibility in choosing and adjusting their power suppliers.[15] Specifically, they can reduce their coal power consumption in three main manners.

First, they can contract less carbon-intensive electricity (e.g. gas) in order to reduce the 'indirect carbon ETS costs'. The second way is by switching to renewable electricity that is exempt from energy taxation to mitigate or avoid the 'indirect carbon costs'. Accordingly, such an increasing use of renewable electricity (zero marginal costs within a certain range) may further reduce spot market prices of power via 'merit order effect' (Sensfuss et al., 2008), which will then put more cost pressure on coal-fired generators. These two ways are practically feasible since electricity suppliers are legally required to disclose to their (final) consumers the source of the electricity they have delivered along with its environmental impact (in terms of at least CO_2 emissions) (European Parliament and Council of the European Union, 2009a). The third approach is to adopt more energy-efficient 'energy-related products' to reduce electricity use. 'Energy-related products' refer to those products that directly consume energy (e.g. vehicles, household appliance such as air conditioning and refrigeration equipment) or influence the consumption of energy (e.g. windows and showerheads).

In the wake of a decreased demand for coal-fired power, coal-fired generators will be in principle incentivized to switch to a more coal-efficient or low-carbon generation to reduce coal/carbon costs, e.g. by adopting carbon capture and storage (CCS), the integrated gasification combined cycle (IGCC) or supercritical/ultra-supercritical (SC/USC) coal-fired generation. Admittedly, such a technique switch could be quite costly and risky.[16] Alternatively, they could inflate the power price to maximize the profits, since electricity demand is generally believed to be inelastic. But this can only be done to a limited extent. This is mainly because with the IDR (double carbon costs) being added to the electricity consumption, real income of power consumers will *de facto* decline (i.e. real purchasing power of electricity is falling), *ceteris paribus*. Accordingly, electricity demand will be more elastic.[17] Coal-fired generators are therefore incentivized to set the power price carefully and to consider more coal-efficient or low-carbon generation techniques.

Still, ultimate decisions should be made based on multiple technical, economic and regulatory factors that may vary among member states or even at different time (e.g. climatic variations). Major concerns include, *inter alia*, the technical possibility of a low-carbon switch, their own generation costs (coal costs included) and carbon costs, the current electricity mix and different prices by source (merit order effects), along with the market power of particular coal-fired generators that is largely affected by the power demand elasticity.

Further, whichever compliance strategy may be chosen by coal-fired generators, they are incentivized to reduce their aggregate carbon emissions and thus the demand for allowances will most likely fall, *ceteris paribus*. In other words, such a drop will take place with or without generators' voluntary abatement efforts. On the one hand, the adoption of coal-efficient or low-carbon generation technique will certainly reduce coal-related emissions. On the other hand, assuming without further abatement efforts, potential decreased sales of coal-fired power – as a result of power price increase – will discourage the upstream generation, which will then reduce the coal-related emissions at the upstream side.

To sum up, the IDR that affects EU's coal-fired power consumers will reduce the emissions of upstream coal-fired power generators

(*footnote continued*)
It may be slightly different in China since the China ETS appears to implement an 'intensity-based' cap that allows for ex-post adjustment of allowances. In this regard, double regulation in China may contribute to additional emission cuts *but* to a limited extent. See Zeng et al. (2016a).

[15] Whether and to what extent current consumers (of coal-fired power) in the EU could lower the consumption depends upon what is written in the contract.

[16] In addition, switching to other generation fuels (e.g. gas) could also be costly because of the rising gas price. See European Commission (2014).

[17] Since the income elasticity of electricity ('necessity goods') is positive (Frank, 2007, p. 96, pp. 121–126; Perloff, 2008), the demand of electricity will further drop when power price increases ('income effects of IDR').

('upstream-downstream effect'). At the same time, aggregate emissions from electricity generation in the power sector will fall. This is mainly because consumers are incentivized to switch to renewable electricity with potential exemptions from the ETD or to utilise more energy-efficient 'energy-related products' (to reduce electricity use). Either way, a more low-carbon generation or a decreased aggregate electricity demand will reduce the overall electricity emissions and thus the demand for allowances within the power sector.

Consequently, a reduced allowance demand from the power sector paired with the 'absolute cap' of the EU ETS (fixed supply) (European Parliament and Council of the European Union, 2009b), a decline of the carbon price is expected which in turn reduces the aggregate abatement costs (efficiency enhanced). However, the indirect interaction of the EU ETS with 'carbon tax' is jeopardizing the environmental functioning of the ETS. This is because such an overlap did not result in lower emissions *but* in a lower ETS price. Since a high allowance price is necessary to incentivize covered entities to invest in technological innovation, research and development (Weishaar, 2014b), such an interaction inevitably undermines the guidance effects of the ETS.

In the long term, further 'water-bed effect' may arise from an increased use of energy-efficient 'energy-related products'. For instance, carbon emitters in the non-ETS sectors (e.g. service sector, building or transportation sector) may release fewer emissions with less power consumed or fewer running hours, leading to further abatement in the non-ETS sectors. With a fixed trajectory of GHG abatement targets in the EU (both the ETS and non-ETS included), abatement pressure of the ETS may be relieved, possibly resulting in a shift of the relative abatement burden from entities covered by the EU ETS to those that are not covered. This in turn would take pressure from the carbon allowance price, *ceteris paribus.*

By contrast, in China, with the IDR (direct carbon ETS costs and indirect 'carbon tax'), coal-fired generators face lots of pressure in terms of reducing coal use and carbon abatement. First, they are directly covered by the ETS and thus incentivized to abate. Second, they pay market prices for coal and are most likely to absorb partial resources tax that is passed from upstream coal plants, mainly because the price elasticity of demand for thermal coal is relatively inelastic (see above in Section 2.2). Third, their carbon costs cannot be passed down easily to downstream grids or consumers due to the fixed and regulated on-grid tariffs. Moreover, coal power generators do not have much leeway in adjusting the output. As a result, coal-fired generators will be incentivized to reduce coal use and abate by, e.g., adopting coal-efficient and low-carbon generation technology. This enhances the environmental effectiveness. Accordingly, their decreased demand for carbon allowances will bring down the carbon price over a certain time period.

However, whether such abatement is efficient remains unknown. Efficiency implies that GHG emissions reduction is achieved at least cost, which is largely influenced by the stringency of abatement targets (Weishaar, 2014a; Zeng et al., 2016). For instance, if the allocation to coal-power plants turns out too stringent and purchasing carbon allowances is not an option (e.g. when the current market price is way too pricy), they will face too much abatement pressure within a short period of time. Accordingly, coal-power generators may have to abate emissions rapidly by investing in the currently available but costly low-carbon technology, adding to the compliance costs (inefficiency) that could have been saved if they were given enough time to develop more efficient abatement. Still, it bears mentioning, such pressure may be relieved in the long term with the 'co-movement' mechanism – developed by China's central government – that allows for partial pass through of coal cost increases (to the on-grid tariff for coal-fired power) (NDRC, 2015a).

3.2. Implicit distortions of the ETS guidance effects

Efficiency requires the minimization of aggregate abatement costs to achieve a pre-determined climate change target. This is obtained when marginal abatement costs are equalized across sectors and emitters, so that reductions take place where they are cheapest to obtain (Weishaar, 2014a). One way of achieving this equalization is by using an instrument mix that sets a uniform carbon price for different sectors and allows for trading such as an ETS. In the absence of transaction costs or market imperfections, the ETS can be considered efficient by itself (Rey et al., 2014).

In the optimum scenario for the ETS, covered entities make abatement decisions solely based on carbon costs that is reflected by a uniform carbon price. But implementing additional instruments (e.g. tax) on the up/down-stream side of ETS entities may distort the carbon price signal and reduce efficiency. For instance, in China, with the indirect 'carbon tax' (coal resources tax) passed from upstream coal plants, ETS-covered entities (i.e. coal-fired power plants) will be encouraged to invest in low-carbon generation technology that brings the most 'net benefits' – including not only 'ETS costs/benefits' but also 'carbon tax'. Accordingly, decision making of coal-fired power plants and thus the ETS guidance effects may be distorted. As a result, aggregate abatement costs of achieving the prescribed target, assuming all else being equal, will arise beyond the costs set in the optimum scenario. By contrast, such distortions will not take place in the EU at the coal-fired power generators, since the consumption of energy products (coal) for generation (covered by the EU ETS) are exempt from 'carbon tax' (energy tax) (Council of the European Union, 2003).

Second, the ETS guidance effects may be impaired by the discrepancy in the declared policy objectives of the chosen instruments. The ETS targets GHG emissions and encourages the development and use of low-carbon electricity. The tax measures considered in this paper are not using the carbon content as a tax base and therefore do not consistently provide incentives to reduce emissions cost-effectively.

Specifically, on the one hand, the EU ETD reflects more concern about competitiveness and distributive impact than the environment (European Commission, 2011b). The ETD sets the same minimum tax rate for the consumption of electricity and only differentiates between business and non-business use. It is further carbon neutral as it does not discriminate between carbon-intensive and low-carbon power (though exemptions for renewables are available) (Council of the European Union, 2003; European Commission, 2016). Altogether, through the 'upstream-downstream effects', the EU ETD and thus the IDR in the EU do not favor the low-carbon fossil fuel (e.g. gas) for electricity generation. On the other hand, the resources tax and thus the IDR in China, however, favor coal-efficient generation or generators with higher demand elasticity for coal (not necessarily low-carbon generation).

Third, further distortion of ETS guidance effects may arise from different tax rates imposed on equal entities among different sectors and regions, which in turn distort the guidance effects of a uniform carbon price.[18] For instance, similar coal power plants in different provinces face different resources taxes in China (see Fig. 3), and the energy taxes imposed upon coal-fired power in the EU vary substantially among countries and sectors (see Figs. 1 and 2). Accordingly, through the 'upstream-downstream effects', abatement incentives that a single ETS price places on coal-fired generators are distorted and competitive concerns arise as well. Consequently, including the 'ETS cost', Tables 4 and 6 present the potential magnitude of regional differences in 'double carbon costs', respectively among the 6 highest emitting countries in the EU and the 5 largest coal-producing provinces in China, covering around 74% of national coal production). For instance, the associated 'double carbon costs' per megawatt-hour of coal-fired power is 21.12 euros in Germany (business) and 8.23 euros in Bulgaria (business).

[18] Similar negative effects – that arise from different environmental taxes rates across regions/countries – have been examined and referred to as 'cross-border effects', e.g. the unintended trade distorting effects between Northern Ireland (with aggregate levy) to Ireland (without levy). See EEA (2008) pp. 26–30, 32–33, Weishaar (2009).

4. Linking the China ETS to the EU ETS: implications of IDR for its linked partner

Linking the EU ETS to the China ETS appears to promise considerable economic and political gains, and both the EU and China expressed willingness to link (European Commission, 2010a; NDRC, 2015b; Macdonald-Smith, 2016; Zeng et al., 2016). Particularly, with the U.S. retreat on climate efforts, EU officials are looking towards China to establish an ‘expanded carbon market’ and to reinforce EU's global climate leadership role (de Carbonnel, 2017). Similarly, China has announced its intention of ‘participating in global climate governance in depth’ (State Council, 2016, Section 9). This demonstrates the country's strong interest in gaining a more prominent role in the area of climate change. Linking the proposed national ETS to the current world's biggest ETS (the EU ETS) will largely serve that goal and China will also benefit from EU's experience.

Consequently, with the political desirability and a long-standing cooperation on carbon markets,[19] an EU-China linkage is likely to materialize in the future. A linkage between world's two largest ETSs, although predicted to be at least seven years off (Macdonald-Smith, 2016), remains a crucial issue towards global mitigation efforts and thus merits further attention. However, different policy choices between jurisdictions (e.g. different ETS designs,[20] double regulation) are likely to impede a potential linking.

With a hypothetical ‘direct and full linkage’ between both ETSs (no linking restrictions),[21] this section analyzes how the IDR identified above in each ETS will affect its linked partner's system and particularly in relation to the carbon abatement incentives of coal-fired generators. Specifically, building upon Section 3, we examine two scenarios associated with a raise in the tax measures (i.e. resources tax in China and the ETD in the EU).

In the case of China, the ‘carbon tax’ (resources tax) that is levied on coal plants for the coal production/sales will be partially passed on to coal-fired generators, as the demand for thermal coal is quite inelastic (e.g. − 0.1397 in the short term). This will then intensify their abatement pressure since generators have already been covered by the ETS. When the resources tax rate in China increases, coal-fired generators will have difficulties passing cost increases on to electricity consumers as the on-grid tariffs are fixed and heavily regulated. As analyzed in Section 3.1, they will have to absorb *pro-rata* inflated coal costs and are further incentivized to employ techniques such as IGCC and SC/USC generation to increase coal use efficiency or directly abate (Yue, 2012). *Ceteris paribus*, carbon emissions of coal-fired generators in China will most likely drop, which will then bring down the demand for allowances and thus put a downward pressure on the carbon price in the linked ETSs. Given the major role coal plays in power generation in China,[22] abatement of coal-fired generators in China is very likely to yield sizeable effects on the carbon price in the linked ETSs. Such effects will be more prominent especially because the Chinese ETS – once fully implemented – is projected to be around twice the size of the EU ETS (Swartz and International Emissions Trading Association (IETA), 2016).

Accordingly, those EU-ETS-covered entities (coal-fired generators included) that are net purchasers of emission allowances will benefit from such a carbon price decline in the jointed markets. Society as a whole would also benefit, since a price decline is associated with enhanced efficiency gains and the abatement target in the EU would be realized at lower costs. At the same time, however, abatement incentives in the EU ETS will be impaired when ‘cheaper’ allowances are leaking into the EU. In the current market situation, however, this effect is expected to be limited as abatement incentives are quite limited. The reason for this is of course the enormous excess supply of allowances within the EU ETS, leading to price levels that are deemed too low to incentivize carbon abatement in phase 3 (MacDonald, 2016; Macdonald-Smith, 2016; Zeng et al., 2016). However, with structural reform measures (e.g. Market Stability Reserve) and a faster reduction of the annual emissions cap later on to address the market imbalance (European Council, 2014; European Parliament and Council of the European Union, 2015), carbon price may slowly bounce back.[23] In this case, when the EU-China ETSs linkage finally materializes in the future – most likely when carbon prices in both ETSs turn ‘positive’ (i.e. prices to be of influence on abatement)[24] – the IDR in China will have noticeable effects on the EU ETS and particularly on the coal-fired generators concerned.

By contrast, in the case of a higher electricity tax in the EU, coal-fired power consumers – that are subject to the double cost burden of the IDR – will further avoid the consumption of coal-fired power. As identified in Section 3.1, this could be done either by switching to renewable electricity in order to lower ‘indirect carbon costs’ and potentially reduce the ‘direct electricity tax’ charged, or it could be done by adopting energy-efficient ‘energy-related products’ to cut the overall electricity needed. Either way, the ‘upstream-downstream effect’ identified in Section 3.1 will be reinforced. That is the decreased demand for coal-fired power will further reduce the emissions in the power sector and thus the demand for allowances, regardless of abatement efforts taken by coal-fired generators in the EU. Also, it bears mentioning that such an effect may vary significantly among different member states (or sectors), as there are strong differences in the effective energy tax rates on electricity (‘pre-linking distortions’, see Section 3.2).

Accordingly, along with an absolute cap (fixed supply) in the EU ETS, the diminished demand for allowances in the power sector will further bring down the carbon price in the linked systems. This may give rise to additional benefits of alleviating abatement pressure on covered entities in both jurisdictions. Despite the power sector is one of the most carbon-sensitive sectors in China (Li et al., 2012), the carbon influence on China's coal-fired power generators remains rather limited in the short term. This is mainly because, as examined above, power generators in China can not easily change their output in the short term, as they are constrained by the heavy electricity regulation. As such, they do not have so much leeway as their counterparts in the EU to expand output and take advantage of the lower carbon price. However, such an effect will be enhanced in the long term, when coal-fired generators have more freedom in adjusting output[25] or with the ‘co-movement mechanism’ that allows for partial pass-through of coal cost increase to the on-grid tariff.

[19] The on-going cooperation provides a high-level political framework for further collaboration. See, e.g., the EU-China Partnership on Climate Change (established in 2005, later confirmed in the 2010 Joint Statement and enhanced in the 2015 Joint Statement); the ‘EU-China emission trading capacity-building project’ (initiated in 2014) to offer EU expertise. See NDRC and European Commission (2010), European Council and Council of European Union (2015), para 3,9(5).

[20] Main concerns with regard to ETS designs include, *inter alia*, differences in abatement targets, transparency and policy inconsistency, robustness of MRV rules and stringency of enforcement within the China ETS. For instance, article 25 of Directive 2009/29/EC stipulates that future links agreements may be made with compatible mandatory ETSs with ‘absolute emissions caps’. Hence, the implementation of ‘intensity-based cap’ in the China ETS may impede a potential EU-China linking. See Zeng et al. (2016).

[21] For the definition of ‘direct’ or ‘full’ linkage, see Haites and Mullins (2001), Sterk et al. (2006), Roßnagel (2008) p. 396, Tuerk et al. (2009) p. 343.
It bears mentioning we examine the linking scenarios without any ‘quantitative or qualitative linking restrictions’ (e.g. ‘quotas’ or ‘border tax’ on the imported/exported allowances).

[22] Specifically, 64% of domestic electricity in China comes from coal in 2016 (China electricity council, 2017).

[23] The current carbon price in the EU ETS, oscillating between €2.97/tCO2 and €17.79/tCO2 since 2009, is far lower than what policymakers initially envisaged but expected to bounce back around 2025 (European Commission, 2010b; Macdonald-Smith, 2016; Sandbag, 2017).

[24] This remains a precondition for linking, which ensures the abatement target in each ETS is stringent *per se*. See Roßnagel (2008), Tuerk et al. (2009), Zeng et al. (2016).

[25] The increased flexibility of coal-fired generation in the long term is embodied by, e.g., a larger value of demand elasticity (for thermal coal) in the long term (0.254) than the value in the short term (0.1397) (Qiao and Luo, 2016).

Table 6
Double carbon cost burdens on coal-fired generators in China (EUR/MWh).
Source: Authors' own calculations on the basis of data from China electricity council (2017), Tianjin Port Exchange Market (situation of 2017-05-10).

	Largest coal-producing provinces (2016)	Standard coal consumption[a] (gCoal/kWh)	Coal price (CNY/tCoal)	Resources tax rate	Resources tax[b] (CNY/MWh)	Resources tax (EUR//MWh)	ETS cost (CNY/tCoal)	ETS cost (CNY/MWh)	ETS cost (EUR/MWh)	Double carbon cost (EUR/MWh)
Bituminous coal – 5000 Kcal/kg	**Inner Mongolia**	312	545	9%	15.30	1.99	75.36	23.51	3.06	5.05
	Shanxi			8%	13.60	1.77				4.83
	Shaanxi			6%	10.20	1.33				4.39
	Guizhou			5%	8.50	1.11				4.17
	Xinjiang			6%	10.20	1.33				4.39
	–			2% (min. rate)	3.40	0.44				3.50
Anthracite – 5500 Kcal/kg	**Inner Mongolia**	312	605	9%	16.99	2.21	86.23	26.90	3.50	5.71
	Shanxi			8%	15.1	1.96				5.46
	Shaanxi			6%	11.33	1.47				4.97
	Guizhou			5%	9.44	1.23				4.73
	Xinjiang			6%	11.33	1.47				4.97
	–			2% (min. rate)	3.78	0.49				3.99

Note: Data on the exchange rate is taken as in 0.13 EUR/CNY (situation of 2017-5-22).
[a] 'Standard coal consumption' applies to typical plants (capacity not less than 6000 kW).
[b] Due to the inelastic demand of thermal coal over the period 2001–2105 (Qiao, 2016), we assumed a 100% pass of coal resources tax to estimate resources tax burdens.

To sum up, an increase in the 'carbon tax' in both jurisdictions will exacerbate the effect of the IDR in both jurisdictions, and give rise to a carbon price decline. This decline is expected to benefit coal-fired power generators in the linked partner's system while slightly discourage their abatement. It is also expected that such effects will be reinforced in the long term, when carbon prices in both ETSs are sufficiently 'positive' to incentivize investment in abatement technology. Moreover, with the current electricity regulation in China, the 'carbon tax signal' will be passed from the EU to China's generators at a much slower pace and to a more limited extent than the other way around.

In the meantime, the pre-linking differences of 'double carbon costs', imposed on similar coal-fired generators between the EU and China, will further cause competitive distortions. To compare such asymmetric effects of 'IDR' on the competitiveness between the EU and China, the 'double carbon costs' – imposed on each megawatt-hour of coal-fired power – are measured in Tables 4 and 6. Specifically, the 'ETS cost per megawatt-hour of coal-fired power (CNY/MWh)' in China is calculated based on the 'standard coal consumption (gCoal/kWh)' from China electricity council (2017) and the 'projected ETS cost (CNY/tCoal)' from Table 5. For instance, there exists a difference of 16.07 EUR/Mwh between Germany (business) and Inner Mongolia (the largest coal-producing province in 2016 and also applying the highest coal resources tax rate in China).

5. Conclusions and policy implications

The primary goal of this article has been to enrich the scientific and policy discussion on 'double carbon regulation' by identifying a serious issue that has been underrepresented, '*indirect double regulation'*. As our findings reveal, it arises from the current carbon regulatory framework in the EU and China, *de facto* shapes the abatement incentive structures of ETS entities (i.e. coal-fired generators) and thus merits further attention.

First, this paper clears up a broad concept – double regulation – that has been interpreted with multiple-but-ambiguous explanations. We identified two categories of 'direct double regulation' that have been discussed in the literature. Double regulation takes place when the same carbon obligations or mitigation efforts are counted twice, either at two separate parties under the same regulatory system (e.g. double crediting between the ERUs and CERs under UNFCCC) or at the same party under two separate systems (e.g. when carbon tax or energy measures directly concern the ETS entities).

Second, two different forms of IDR are identified in the EU and China by scrutinizing legal documents on coal-related carbon regulation and examining abatement incentive structures of coal-fired generators from a Law & Economics perspective. Specifically, in the absence of *de jure* carbon tax in China or EU widely, energy tax (on coal-fired power) in the EU and resources tax (on coal) in China – as '*quasi* carbon tax' – may *de facto* constitute IDR in co-existence with each ETS. This paper further presents the empirical evidence of IDR (double carbon cost burdens) with a preliminary estimation of the magnitude in both jurisdictions (see, e.g., Tables 4 and 6).

Third, further mixed effects of IDR are examined for both jurisdictions with an explicit carbon price drop (*prima facie* efficiency gains) and further implicit distortions. In the EU, IDR takes place at the coal-fired power consumers, *ceteris paribus,* reducing emissions from the upstream coal-fired generation (via 'upstream-downstream effect') in the short term and increasing the supply of allowances within the ETS (through 'water-bed effect') in the long run. By contrast, similar problem arises in China at coal-fired generators that will then put them under lots of pressure in terms of reducing coal use and abatement (Section 3.1). Altogether, IDR – despite at different parties between both jurisdictions – could incentivize a low-carbon transfer of coal-fired power system, while the seemingly uniform carbon signal may be further complicated by implicit distortions (Section 3.2).

In response to the distorting effects of IDR on the ETS guidance efforts, specific measures can be taken but should differentiate distortions by sources.

For one thing, to mitigate distortions that arise from the discrepancy between the policy objectives of both instruments ('carbon tax' and the ETS), policy-makers can introduce a carbon element into energy taxation or resources tax, i.e. to tax the electricity consumed (in the EU) or the thermal coal (in China) more consistently with their carbon content.[26] As mentioned above, similar idea was previously proposed by the former Finance Minister (Jiwei Lou) in China, and by the European Commission but withdrawn mainly for competiveness concerns (e.g. from the diesel industry). By restructuring the existing taxation to a carbon focus, not only the *de-facto* distortions from existing policy instruments (i.e. IDR) can be largely mitigated, but the legal/administrative burdens of implementing a new tax item (e.g. carbon tax in

[26] Legally speaking, this does not constitute 'double carbon regulation' as both the ETS and 'tax' concern separate parties.

China) can also be avoided.

For another, the uniform carbon signal may be further distorted by *de facto* regional/sectoral tax differences among equal entities of both jurisdictions. It would be mistaken, however, to simply eliminate such differences in energy/resources tax, since they may reflect other policy considerations. For instance, as analyzed above, energy tax rates are set differently among EU member states largely for competitiveness concerns in the internal (energy) market. It does not necessarily go so far as to sacrifice the competitiveness consideration for abatement purposes, and the European Court of Justice also adjudicated 'emissions reduction' (as principal objective) must be attained in compliance with other sub-objectives (competitiveness included) (para. 79 in Case C-505/09 P Commission v Estonia [2012] ECR, ECLI:EU:C:2012:179). Rather, both objectives should be taken as a whole so as to minimize unnecessary regulatory burdens by considering a dynamic carbon-energy market relationship and trade-offs between policy interests. Specifically, the co-existing ETS and energy/resources tax could be collectively subject to 'proportionality test' regarding the suitability, necessity and 'excessive effects' (art. 5, Treaty on European Union).

Furthermore, our findings can be used to complete the competitiveness discussion for the EU ETD, as previous arguments largely concentrate on the energy market. But as Section 3.2 reveals, the EU ETD – that was designed to reduce competitive concerns for the internal (energy) market – may become a source of competitive distortions in the carbon market.

Additionally, this paper also seeks to enrich scientific and policy discussion on ETSs linking by examining the implications of double regulation for its linked partner (Section 4). Double carbon regulation remains a concern that has not yet arisen from the current linking-literature or ETSs-linking practices (e.g. California-Quebec or EU-Swiss linkage). But if the ETSs linkage is to happen, not only 'ETS designs' but other (carbon) regulatory features (e.g. energy/resources tax) may also significantly affect the abatement decisions of ETS entities (e.g. coal-fired generators) in the joint ETSs. In the eventuality of a EU-China linkage, although only likely in the longer term, our findings suggest that IDR does serve to alleviate abatement pressure on coal-fired generators in its linked partner's system while slightly discourage their abatement.

It may further prove crucial to include 'double regulation' into future EU-China linking negotiations due to its potentially asymmetric effects on the competitiveness of both systems (see, e.g., Tables 4 and 6) and their sizeable share of global emissions. Specifically, the 'carbon tax signal' may be passed from the EU to China's generators to a much more limited extent than the other way around. In other words, the joint ETSs – together with the pre-linking distortions that arise from IDR – are not providing a level playing field in terms of abatement for equal coal-fired generators in both jurisdictions.

Admittedly, our findings cannot be conclusive. For one thing, the qualitative evaluation *herein* lays the theoretic framework to better understand the interactive rationale of IDR, with systematic inclusion of relevant factors (e.g. legal designing details of the ETS/taxes, market characteristics) that shape abatement incentives of coal-fired generators. For another, the quantitative evidence *herein* presents a preliminary magnitude of IDR (e.g. double carbon cost burdens) for coal-fired generation before and after linking. A better understanding of dynamic effects calls for future research conducted in both qualitative and quantitative manner.

Further quantitative ex-ante simulation or ex-post empirical-based observations will contribute to a statistically reliable sense of the magnitude of effects. Two major clusters have been employed in the literature to quantitatively examine policy interactions, and both approaches may have merits and disadvantages once applied.

On the one hand, bottom-up energy system models (e.g. the MARKAL bottom-up energy model) concentrate on the energy sector entirely (see, e.g., Kannan and Strachan, 2009; Qudrat-Ullah, 2013). Specifically, the disaggregated data applied may better capture the regional disparities (e.g. in energy/resources tax, technical possibility of abatement, electricity mix or State-aid measures) and describe thoroughly how coal-fired generators among different regions react differently ('implicit distortions of IDR').

On the other hand, top-down sectoral modelling approaches largely focus upon the 'interactions of the energy sector with the rest of the economy' such as input–output models and Computable General Equilibrium (CGE) models (Qudrat-Ullah, 2013). For instance, the optimization analytical methods adopted could be used to optimize abatement decisions (of coal-fired plants) endogenously while meeting the given concurrent constraints of interacted tax-ETS. Hence, it may prove more feasible (than the bottom-up counterparts) for the EU but may be less applicable in the Chinese electricity market context, since optimization generally works best for competitive markets (see, e.g., Oikonomou et al., 2008; Fankhauser et al., 2010).

However, it would be mistaken to assume no significance for further qualitative research. Quantitative assessment has significant advantages of estimating the magnitude of IDR. But it tends to focus on the impacts at a market level as a whole (Spyridaki and Flamos, 2014) and the design features (e.g. intricate tax designs or energy/carbon market features) in the final outcome may be underrepresented. In this regard, qualitative assessment may better explain how certain design feature shapes the ultimate outcome, specifically, by integrating intricate but often non-quantifiable cause-and-effect process and addressing the trade-offs between diversified policy designs. A 'multi-criteria based evaluation' may further allow for participatory analysis (see, e.g., Del Río, 2010; Oikonomou et al., 2010). Altogether, a hybrid qualitative-quantitative analysis of IDR can lead to a greater depth of understanding on how the ETS and 'carbon tax' interacted in the generation-consumption chain of coal-fired power, so as to answer the ultimate question how they might be reconfigured to lead to a better mix.

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